

Technical Report M4

**SEDIMENTATION AND NAVIGATION STUDY OF THE
MISSISSIPPI RIVER
AT SEMO PORT,
MILES 49 TO 47**

HYDRAULIC MICRO MODEL INVESTIGATION

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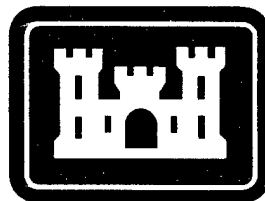
Sedimentation Study of the

Mississippi River at SEMO Pond

River Miles 49 to 47

Hydraulic Micro Model Investigation

Volume 1 of 1



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14. ABSTRACT A sedimentation study of the Mississippi River at SEMO Port, between Miles 49 and 47, was conducted by the U.S. Army Corps of Engineers, St. Louis District. The study was undertaken in order to examine depositional trends experienced within Southeast Missouri Port and determine, if possible, remedial measures to minimize this deposition from various structural alternatives. Using a micro model with a scale of 1 inch=300 feet horizontal and 1 inch=100 feet vertical, the study determined that deposition was a result of the settlement of fine materials from water entering the port during high flow events. An extension of an existing berm surrounding the port was proposed to minimize water entering the port during high flow events. In addition, a series of Bendway Weirs in the adjacent Mississippi River navigation channel were proposed to minimize bed load contribution at the port entrance.					
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INTRODUCTION

A sedimentation study of the Lower Mississippi River at Southeast Missouri Port, Mile 48.0 R, was initiated by the Potamology Section of the St. Louis District. The purpose of the study was to evaluate a number of design alternatives and/or modifications to decrease the need for maintenance dredging in SEMO Port.

The study was conducted between October 1997 and July 1999, using a physical hydraulic micro model at the Applied River Engineering Center, St. Louis, Missouri. The study was performed by Mr. James Abbott and Mr. Adam Goetz under direct supervision of Mr. Robert Davinroy, District Potamologist for the St. Louis District.

Personnel also involved and overseeing the study included Mr. Claude N. Strauser, Chief of the Hydraulics Branch Mr. Steve Redington, Chief of the River Engineering Unit. Mr. Steve Dierker, dredging project engineer, provided invaluable insight into the historical dredging problems. Mr. Dan Overbey of SEMO Port was instrumental in providing technical assistance, data, and plans.

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BACKGROUND

This report details the investigation of a sedimentation and navigation study using a physical hydraulic micro model. The micro model methodology was used to evaluate sediment transport and flow conditions in the Mississippi River at SEMO Port (Mile 48.0 R). Plate 1 is a vicinity map of the study reach.

Micro modeling methodology was used to evaluate the sediment transport and hydrodynamic response trends that could be expected to occur in the river from various design alternatives. These alternatives were conceptualized and submitted by members of a study team including St. Louis District personnel and various representatives of the navigation industry. The primary goal was to evaluate the impacts of these measures on the resultant bed configuration (sediment transport response) and hydrodynamic response (flow patterns) within the study reach.

1. Problem Description

The construction of SEMO Port was completed in May 1988. The port is located on the right descending bank of the Mississippi River at Mile 48. The port is approximately 230 feet wide and 1800 feet long. Since the operation of the port, periodic maintenance dredging has been required. Plate 2 is a summary plot of the historical dredging that has been conducted in SEMO Port.

Prior to the construction of the harbor and river road in 1995, high water flowing over the floodplain entered the backside of the port from the northwest. During these high stages, water flowed through the port and toward the harbor entrance with the main river channel. As the water level decreased, the silt and suspended sediments settled out of the water and into the port. Detailed,

hydrographic surveys collected prior to 1995 indicated greater deposition toward the backside of the port and lesser deposition toward the entrance. This trend verified that the sediment deposits within the harbor prior to 1995 were a result of floodplain, sediment laden flows entering the backside of the port. Plate 3 is aerial photograph showing floodplain flow entering the backside of the port during the flood of 1993.

After the flood of 1995, additional construction was initiated in SEMO Port. The land area around the backside (west end) and the adjacent side (north side) to the main river channel were raised to an elevation of 355 NGVD. The harbor road was extended across the west end, and the river road was extended out along the north side. The raised berm of the river road extended out to approximately 245 ft from the natural bankline at the most upstream point of the port. Since the completion of this road construction, no flood flows have entered the port from the back side. A pre-construction photograph of the berm construction is shown on Plate 4, and a post construction photograph is shown on Plate 5. Plate 6 shows a photograph of both the berm and river road.

After completion of this construction in 1996, there has still been a need for periodic, maintenance dredging (Plate 2). Detailed hydrographic surveys collected after 1996 indicated that depositional patterns within the harbor had changed. Deposition had a tendency to increase closer toward the entrance to the port and lessen toward the back of the port. This trend was just the opposite of what was observed prior to 1995. In addition, the volume of material into the port had increased. The possibility existed that although "backside" flood flows had been eliminated, sediment laden, high water after 1995 had entered the port from the main river channel. This trend was verified in the micro model by visual observation tests using and is discussed later in this report.

2. Field Reconnaissance

Field reconnaissance of SEMO Port was conducted by Mr. Robert Davinroy, Mr. James Abbott, and Mr. Adam Goetz in the fall of 1998. The following observations were noted:

- There were two flow eddies that were observed at the mouth of the port. Plate 7 contains photo schematics showing the approximate size and location of these eddies. The larger primary eddy, a result of the downstream dike at 47.9 R, caused currents to flow in an upstream direction directly adjacent to the entrance of the port. The secondary, smaller eddy was located within the first 100 feet of the port.
- Plate 8 shows a profile view of the berm looking out toward the entrance to the port. It was apparent from this view that a large amount of water could enter into the port during high flow events. At the time of the field trip, the water inside the majority of the port was stationary.
- The adjacent banks of SEMO Port contained many large erosion ditches. The surrounding ground and bank of SEMO Port was very soft and contained a large amount of fine materials. It was evident that high water and heavy rains had washed some of the local topsoil into the port. Plate 9 shows the location of these ditches. Some ditches were as deep as five feet. Mr. Dan Overbey of SEMO Port performed detailed volumetric computations of this erosion and concluded that sediment contributions from these ditches into the port were insignificant and were not a primary contributor of the historical deposition.

3. Study Purpose and Goals

The purpose of this study was to address the sediment transport response and interaction between the main channel and SEMO Port, and to analyze design alternative impacts in the vicinity of the port.

The goal was to alleviate or eliminate the need for annual maintenance dredging within the port. Several different design alternative schemes were tested in the model and compared to an established base condition.

MICRO MODEL DESCRIPTION

1. Scales and Bed Materials

Plate 10 is a photograph of the SEMO Port micro model. The model study reach was between Miles 49 and 47. The scales used were 1 inch = 300 feet horizontal, 1 inch = 50 feet vertical, for a 6 to 1 distortion ratio. This distortion supplied the necessary forces required for the simulation of sediment transport conditions similar to the prototype. The bed material was granular plastic urea, Type II, with a specific gravity of 1.23.

2. Appurtenances

Discharge hydrographs were simulated by computer via an electronic control system. A 3-dimensional digitizer was used to monitor water stages and to measure and record the resultant model bed configurations.

The model was constructed according to aerial photography of the study reach. The riverbanks were constructed out of dense polystyrene, while the realignment section at the confluence was constructed out of oil-based clay. Rotational jacks located within the hydraulic flume controlled the slope of the model.

Surface current patterns were captured using a flow visualization technique developed at AREC. This technique involved using photographic time exposure prints to examine the general surface velocity patterns of the base test and of most design alternative tests. Dye was also used to show underwater current patterns.

MICRO MODEL TESTS

1. Calibration

The calibration of the micro model involved the adjustment of water discharge, sediment volume, hydrograph time scale, and slope. These parameters were refined until the measured bed response of the model was similar to that of the prototype.

A. Design Hydrograph

In all model tests, the effective discharge or hydrograph was simulated in the Mississippi River channel only. This hydrograph served as the average design flow response. Because of the constant variation experienced in the prototype, a design hydrograph was used to theoretically analyze the average expected sediment response during any given year. The time increment or duration of each cycle (peak to peak) was three minutes. Peak stage where maximum energy of the model was achieved was +10 LWRP.

B. Suspended Sediment

The majority of deposition that has occurred within SEMO Port in the past has been related to the settlement or fallout of fine suspended sediments from the water during high flow events. Past dredging records indicated that the majority of material dredged within the port consisted of fine silts and clays, further verifying suspended sediment deposition. Due to the extremely fine consistency of this material, the dredge disposal involved placement into nearby upland, confined areas in order to satisfy state water quality requirements. IN recent years, dredged material had been placed directly back into the adjacent river channel, within the scour hole off the end of Dike 47.9 L. Detailed hydrographic

surveys indicated that placement of dredged material into this scour hole had caused no negative impacts downstream. Surveys indicated that the placed material was quickly assimilated into the natural transport characteristic of the river, and no increased deposition occurred downstream from the placement point.

The micro model did not directly simulate the effects of suspended sediment deposition within the port. The model addressed comparative changes to the bed of the river. Standard micro model tests were conducted to compare relative changes to the bed of both the main channel and at the mouth of the port, where typical deposition of bed material can be expected to occur.

However, several visual tests were performed in the model using dye to simulate suspended sediment within the water column and to generically observe high flow patterns at SEMO Port. These tests were considered outside the normal, intended use of the Micro Modeling tool, and thus were not documented or analyzed to any detailed effort. Plate 23 is a photograph of the model illustrating the use of this dye. The tests were performed in the model to visually observe high water entering into the backside of the port and to examine the general effects of allowing high water to enter into the port from the main channel only. Observations indicated that of the two scenarios, the later event seemed to generate a greater potential for the settlement of fine material into the port.

Dye was also placed within SEMO port during all micro model tests to visually observe flow within the port during the course of the model design hydrograph.

C. Prototype Surveys

All hydrographic and model surveys (bathymetry) in this study were prepared as color-coded contour elevations with respect to the Low Water Reference Plane (LWRP). The surveys from the prototype were of two categories: surveys taken to define the navigation channel, and surveys taken to describe pre and post dredging conditions of SEMO Port.

Plate 11 is a 1995 hydrographic survey of the Mississippi River in the study reach taken prior to the construction of 13 Bendway Weirs. The survey indicated the following trends:

At the upper end of the survey, between Miles 49.4 and 48.5, the thalweg developed along the right descending bank, with depths at approximately -30 feet LWRP. The thalweg remained along the right descending bank through the entire survey. However, there were areas where the thalweg was not well defined and depths were near -10 feet LWRP, between Miles 48.7 and 48.4, between Miles 48.2 and 47.9, and intermittently between Miles 47.7 and 47.0. A scour hole developed off the end of Dike 47.9 R, with depths between -20 feet and -40 feet LWRP.

Plate 12 is a 1995 hydrographic survey taken immediately after the construction of the 13 Bendway Weirs located along the outside of the bend, between Miles 49.5 and 48.3. The survey indicated the following trends:

The scour trends that were developed along the right descending bank in the previous survey, between Miles 49.5 and 48.8, were changed due to the Bendway Weirs. Scour to depths near -30 feet LWRP was developed off the end of Weirs 49.4R, 49.3R, 49.2R, and 49.0R. The scour continued to develop off the ends of Weirs 48.9R and 48.8R, but to depths near -20 feet LWRP. Between Weir 48.7R and the end of the survey, the thalweg remained along the right descending bank, with depths near -20 feet LWRP.

Plate 13 is a 1996 hydrographic survey taken approximately one year after the construction of the Bendway Weirs. The survey indicated the following trends: Scour trends remained off the ends of Weirs 49.3R, 49.2R, 49.1R, and 49.0R, to depths between -30 feet and -50 feet LWRP. Scour also was observed off of Weirs 48.9R and 48.8R, with depths near -20 feet LWRP.

Between Miles 48.9R and 48.3R, the thalweg was not clearly defined, with depths between -10 feet and -20 feet LWRP. Between Miles 48.3 and 47.6, the thalweg was well defined, with depths generally near -20 feet LWRP. Scour was observed off the end of Dike 47.9 R, with depths near -40 feet LWRP.

Thalweg depths were near -10 feet LWRP at Mile 47.5. Below Mile 47.5 to the end of the reach, thalweg depths were near -20 feet LWRP.

Plate 14 is a 1998 hydrographic survey taken approximately 3 years after construction of the Bendway Weirs. The survey indicated the following trends: Scour trends remained off the ends of Weirs 49.4R, 49.3R, 49.2R, 49.1R, and 49.0R, with depths near -30 feet LWRP. Scour was also observed off the ends of Weirs 48.9R and 48.8R, with depths near -20 feet LWRP.

Between Miles 48.8 and 48.5, thalweg depths were between -10 feet and -20 feet LWRP. From Mile 48.5 to the end of the reach, depths were generally near -20 LWRP.

The general trends of the prototype since the construction of the Bendway Weirs indicated that scour pattern once observed on the outside of the bend, between Miles 49.4 and 48.8, had been dramatically changed. Since weir construction, scour had developed off the end of the first seven to eight weirs along the middle to inside of the bend. This trend has remained constant. There has also been a trend for a somewhat relatively shallower channel in the middle of the weir field along the right descending bank, between approximately Miles 48.8 and 48.4.

Plates 15, 16, 17, 18, 19, and 20 are pre-dredge surveys conducted in SEMO port, between 1991 and 1996. The surveys indicated the following trends,

Deposition has periodically occurred in the harbor to approximate depths between -10 feet LWRP and 0 feet LWRP. There has been the tendency for the formation of a small scour hole at the entrance to the port, with depths near -10 feet LWRP.

Several channel sweep surveys of the port have been periodically taken since the early 1990's. These surveys generated much more detail and resolution, but were not included in this report. However, the surveys were carefully examined and studied as part of this initiative and indicated an important trend critical to the mechanics of deposition in the port. Sweep surveys taken prior to the construction of the river road and berm in 1995 indicated that deposition had a tendency to form at higher elevations from the back side of the port toward the river. This trend, combined with the examination of historical flood photos, further verified that deposition was a result of suspended sediment entering the backside of the port. After berm construction, sweep surveys indicated that deposition formed at higher elevations closer to the port entrance. All historical surveys indicated the formation of a scour hole at the entrance to the port.

2. Base Test

For this particular study, two base tests were established to capture the recent Bendway Weir construction in the Mississippi River. The first base test in the model represented the pre-construction condition of the model without the Bendway Weirs. Plate 21 shows the resultant bed configuration of the base test without weirs. Results indicated the following trends:

Scour developed along the outside of the bend along the right descending bank, between the upper end of the model near Mile 49.5 to Mile 48.7. Depths were between -20 feet and -30 feet LWRP. This scour trend was very similar to what was observed in the pre-construction survey of 1995.

Between Miles 48.7 and 48.4, the thalweg had a tendency to shallow, with depths between -10 feet and -20 feet LWRP. This trend was very similar to what was observed in the prototype survey of 1995.

Between Miles 48.3 and 48.2, depths that developed in the thalweg were near -20 feet LWRP, which was similar to the prototype. Directly in front of the port, depths were between -10 feet and -30 feet LWRP, which was 10 feet to 20 feet deeper than the prototype.

Scour developed off the end and downstream of Dike 47.9 R to depths near -30 feet. Scour was also observed against the right descending rock bluff protrusion at Mile 47.8, with depths near -30 feet LWRP. Scour in the prototype was also observed in these areas, as reflected in the pre-dredge surveys of December 1994 (Plate 16), December 1995 (Plate 18), and October 1996 (Plates 19 and 20).

Between Dikes 47.9R and 47.6R, shoaling occurred off the right descending bank, to depths between 0 feet and -10 feet LWRP. This trend was also observed in the prototype.

Scour was generated off the end of Dike 47.2R, with depths near -20 feet LWRP. This trend was also observed in the prototype. Between Dikes 47.6R and 47.2R, deposition occurred in the model off the right descending bank, with depths between +10 feet and 0 feet LWRP. In the prototype, the limits of the survey did not extend far enough between the dikes to determine the extent of this deposition.

The base test without weirs generally replicated the trends observed in the prototype survey, with the exception of shallower depths developed directly within the port off the right bank as compared to the prototype surveys.

Plate 22 shows the resultant bed configuration and flow visualization of the base test with Bendway Weirs. Results indicated the following trends:

Scour developed off the ends of the weirs similar to what was observed in the post construction prototype surveys of 1995, 1996, and 1998, between Miles 49.4 and 49.0, with depths between -20 feet and -30 feet LWRP.

Between Miles 48.8 and 48.5, the thalweg shallowed to depths near -10 LWRP, which was similar to the shallowing trend observed in the prototype. Between Miles 48.3 and 47.6, scour developed along the right descending bank and off the end of Dike 47.9R, to depths near -30 feet LWRP. In the prototype surveys, depths were generally 10 feet less through this area.

From Mile 47.6 to the end of the model, depths in the channel were near -10 feet LWRP. Depths through this area in the prototype were between -10 feet and -20 feet LWRP.

As with the previous base test, there was a depositional trend observed off the right bank of the port near the mouth.

In addition to the bathymetry collected from the model, flow visualization information was also recorded during the base test condition with weirs. Photographic time exposure was used to examine the general surface velocity patterns of the base test and a few of the alternative tests.

The flow visualization (Plate 22) of the base test with weirs, representative of average flow conditions, showed that most of the flow was concentrated along

the outside of the bend against the right descending bank. An eddy was observed above Dike 47.9 R similar to what was observed in the prototype (Plate 7). A smaller secondary eddy was also developed just within the port similar to the secondary eddy observed in the prototype. The water within the back of the port beyond this eddy did not move during the base tests nor all alternative tests. Surface floats and dye (Plate 23) were placed within the boundaries of the port to verify this observation. The only movement in the port was the secondary eddy that formed just inside the mouth of the port. The dye remained stationary within most of the port during this test and all proceeding tests.

3. Design Alternative Tests

A number of alternative plans were tested in the model. As previously discussed, all tests were initiated in the hopes of decreasing the relative deposition of bed sediment in the port while maintaining or improving the existing river channel. The effectiveness of each alternative was evaluated by comparing the resultant bed bathymetry of the alternative test with the resultant bed bathymetry of the base test with weirs.

The base tests and the first two alternatives were conducted in the model with a different boundary condition at the port entrance. During these tests, the boundary around the upstream point of the port was configured according to aerial photography. However, during the course of the study, further investigations determined that submerged rock was located around this upstream point. This rock was identified and placed within the model for alternatives three through five. The rock had a tendency to remove the depositional trend observed off the right bank of the port near the mouth and developed the scour trend observed in the prototype.

All of the alternative tests conducted in the model were initiated in order to evaluate changes in the flow and bed sediment conditions at the entrance to the port. The alternatives addressed bed sediment changes only, and did not address suspended sediment deposition. The model did not contain suspended sediment. The goal was to develop structural alternatives that would direct more flow away from the port thereby minimizing the amount of suspended sediments that would deposit within the port.

Alternative 1: Four Bendway Weirs at -15 LWRP, Angled 30 Degrees into Flow, Between Miles 48.2 and 47.8, Dike 47.9 R Removed. Plate 24 is a map of the resultant bed configuration and flow visualization of Alternative 1. Test results indicated the following results:

Channel depths decreased in front of the port, between Miles 48.4 and 48, to depths between -10 feet and -20 feet LWRP. The adjacent width of the navigation channel (the -10 feet LWRP contour) widened approximately 100 feet at Mile 48, and narrowed approximately 300 feet near Mile 47.5. Greater deposition was experienced at the entrance to the port as compared to the base test, with depths between -10 feet and 0 LWRP.

Flow visualization showed that a large eddy still developed in front of the port. The downstream rock bluff protrusion at Mile 47.8 R became the controlling factor for the development of this eddy. The thalweg of the channel deflected off this point. Observations during this test indicated that the eddy was narrower and more concentrated than compared to the base test.

Dye placed within the port indicated that during this test, the majority of water within the boundaries of the port was stationary.

Alternative 2: Seven Bendway Weirs at -15 LWRP, Angled 30 Degrees into Flow, Between Miles 48.2 and 47.7, Dike 47.9 Removed.

Plate 25 is a plan view contour map of the resultant bed configuration of Alternative Two. Results indicated that depths became shallower along the thalweg of the channel in front of the port, between -10 feet and -20 feet LWRP. Greater deposition was experienced at the entrance to the port as compared to the base test, to depths between -10 feet and 0 feet LWRP. The channel widened slightly in front of the port approximately 200 feet, but narrowed further downstream near Mile 47.8 by approximately 400 feet.

Dye placed within the port indicated that during this test, the majority of water within the boundaries of the port was stationary.

Alternative 3: Three Bendway Weirs at -15 LWRP, Angled 20 Degrees into Flow, Between Miles 48.2 and 48.1, Underwater Rock Added at Point.

Plate 26 is a plan view contour map of the resultant bed configuration of Alternative Three. Results indicated that depths became shallower along the thalweg in front of the port, to depths between -20 feet and -30 feet LWRP. The navigation channel widened approximately 500 feet near Mile 48.

Depths at the entrance to the harbor were approximately 10 feet deeper than the base test. Flow visualization showed the eddy trends in front of the harbor were similar to the base test.

Dye placed within the port indicated that during this test, the majority of water within the boundaries of the port was stationary.

Alternative 4: Three Bendway Weirs at -15 LWRP, Angled 40 degrees into Flow, One Bendway Weir Angled at 30 Degrees into the Flow, Underwater Rock Added at Point.

Plate 27 is a plan view contour map of the resultant bed configuration of Alternative 4. Results indicated depths decreased in the thalweg in front of the port. The width of the navigation channel in front of the port was basically the

same as compared to the base test. Depths at the entrance to the port deepened approximately 10 to 20 feet. Flow visualization showed that the eddy in front of the port was unchanged.

Dye placed within the port indicated that during this test, the majority of water within the boundaries of the port was stationary.

Alternative 5: Dike 47.9 Removed, Right Descending Bankline Filled at Mile 48.0, Underwater Rock Added at Point.

Plate 28 is a map of the resultant bed configuration of Alternative 5. Results indicated that depths were 10 to 20 feet deeper at the entrance to the port as compared to the base test. Scour was more concentrated along the right descending bank in front of the port as compared to the base test. The removal of the Dike at 47.9 and the fill along the right descending bankline still did not minimize the formation of the eddy in front of the port. The navigation channel was narrower at Mile 47.9 as compared to the base test. Depths became excessively shallow in the navigation channel near the end of the study reach, with depths near 0 LWRP.

Dye placed within the port indicated that during this test, the majority of water within the boundaries of the port was stationary.

CONCLUSIONS

1. Summary of Model Tests

- Alternatives one, two, and five indicated that the removal of Dike 47.9R did not eliminate the eddy formation at the entrance to the port. The eddy seemed to be faster and more concentrated as compared to base test conditions. In addition, these tests indicated that the navigation channel had a tendency to narrow adjacent to the original location of the dike.
- Alternatives three, four, and five indicated that the existing underwater rock formation located off the upstream point of the port generated deeper depths at the entrance to the port. This physical feature seemed to generally improve conditions at the entrance to the port.
- Alternative four indicated that three Bendway Weirs placed in the navigation channel, in combination with the natural underwater rock formation, generally improved conditions at the entrance to the port.
- Dye placed within the port during the base test and design alternative tests indicated that there were no currents within the majority of the port during low to midbank flow conditions. The two eddies that developed at the entrance to the port had a localized effect on the dye and flow, but only directly at the entrance area (the first 100 feet of the port).
- Visual observation tests using dye at high flows (flows exceeding the top of the insert in the Micro Model) indicated that suspended sediment may be deposited within the port from flood flows both prior to and after the construction of the berm. Tests conducted at high flow with the existing berm

configuration indicated that flows from the main river channel had a tendency to push the main eddy well into the port. During this condition, more water moved within the port as compared to normal conditions. The dye that normally had a tendency to remain within the port during the model tests was pushed out of the port and replaced with the clearer water from the main channel. This would indicate that the potential for deposition of fine material into the port from the main channel during high flow conditions is highly probable.

2. Recommendations

Measures to reduce the amount of water entering the port during high flows from the river channel should be taken to minimize the deposition of fine suspended sediments. This can be achieved by extending the existing berm riverward from the present endpoint. Plate 29 is a conceptual plan of the proposed berm extension. By extending the berm endpoint riverward approximately 200 feet from the present location, the new boundaries of the port would significantly reduce high flows entering into the port. High flows curtailing around the present upstream boundary formed by the existing berm would essentially be eliminated. The berm extension would force flows out toward the main channel, thereby encouraging the formation of an eddy in front of the port entrance and not further back into the port.

Measures to reduce the amount of bedload entering the port may be achieved by placing three additional Bendway Weirs in the main channel upstream of the port. The weirs would encourage flows to be diverted away from the outside of the bank during normal flow conditions.

Of the two measures discussed above, the berm extension is of the greatest importance in minimizing the deposition and annual dredging that has been experienced within the port.

In the interpretation and evaluation of the results of the tests conducted, it should be remembered that the results of these model tests were qualitative in nature. Any hydraulic model, whether physical or numerical, is subject to biases introduced as a result of the inherent complexities that exist in the prototype. Anomalies in actual hydrographic events, such as prolonged periods of high or low flows are not reflected in these results, nor are complex physical phenomena, such as the existence of underlying rock formations or other non-erodable variables.

FOR MORE INFORMATION

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David.Gordon@mvs02.usace.army.mil

Or you can visit us on the World Wide Web at:

<http://www.mvs.usace.army.mil/engr/river/river.htm>

APPENDIX

Plate #'s 1 through 29 follow:

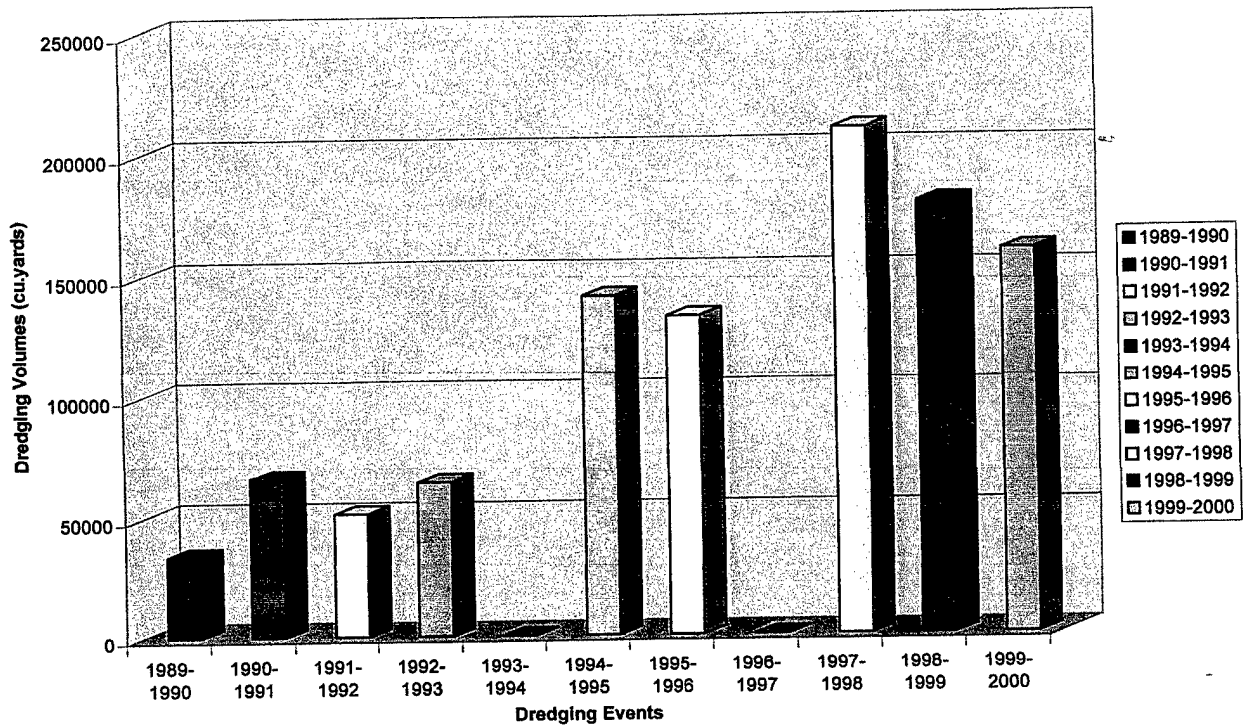
1. Vicinity Map and USGS Quad Sheet of the Study
2. SEMO Port Historical Dredging
3. Flood Photograph
4. Aerial Photograph of the SEMO Port prior to the construction in 1995
5. Current Aerial Photograph of the SEMO Port
6. Photograph Showing the configuration of SEMO Port
7. Photographs of observed eddies during field reconnaissance
8. Photograph showing the berm and river road
9. Diagram of erosion ditches
10. SEMO Port micro-model
11. February 1995 Hydrographic Survey
12. August 1995 Hydrographic Survey
13. 1996 Hydrographic Survey
14. September 1998 Hydrographic Survey
15. December 1991 Hydrographic Survey
16. December 1994 Hydrographic Survey
17. August 1995 Port Survey
18. December 1995 Hydrographic Survey
19. October 1996 Hydrographic Survey (dredge survey)
20. October 1996 Hydrographic Survey (Blankenship sounding)
21. Base Test With Out Weirs
22. Base Test With Weirs
23. Flow visualization of the port area using dye
24. Alternative 1
25. Alternative 2
26. Alternative 3

27. Alternative 4

28. Alternative 5

29. Diagram of Proposed Berm Extension

SEMO Port Historical Dredging



U.S ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: A. Cheney
CHECKED BY: R. Dawsey

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49-47

SEMO Port Historical Dredging

PLATE NO.

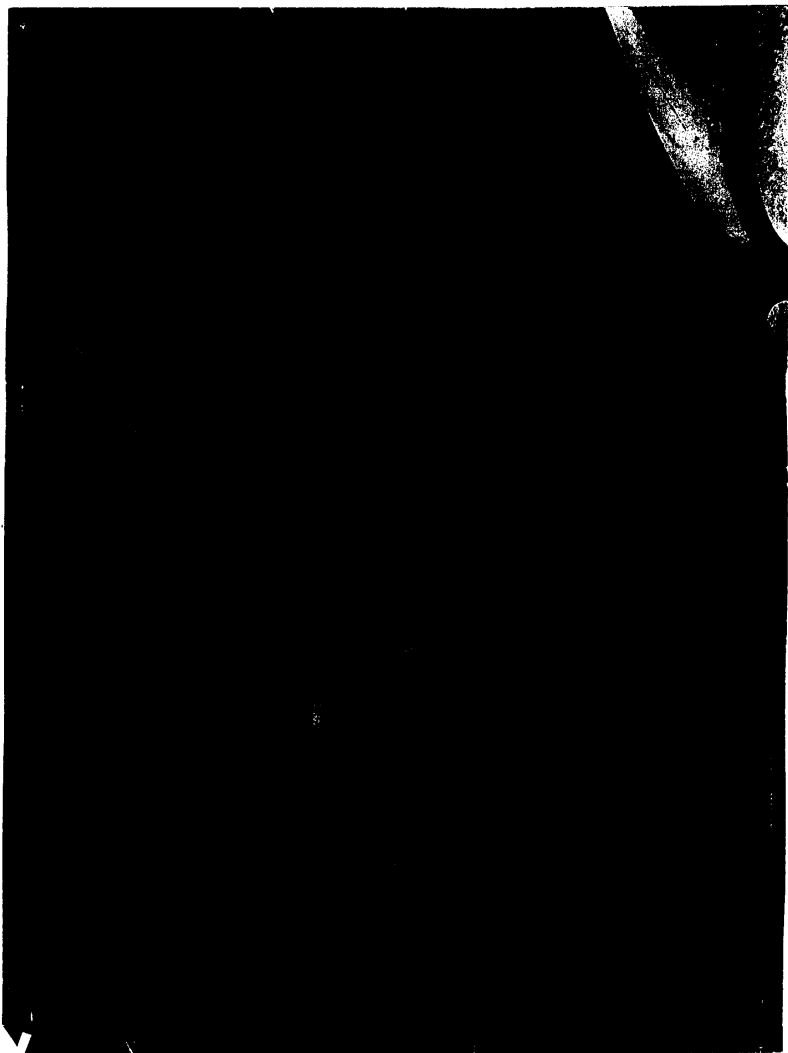
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Area of Interest

NOTE: JULY 10, 1993 - STAGE 42.72

	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS
PREPARED BY: J. Adams CHECKED BY: R. Gentry	SEMO PORT MICRO MODEL STUDY RIVER MODEL 49 - 47 FLOOD PHOTOGRAPH
DESIGN FILE: FLOODPHOTOJAB PLOT SCALE:	PLOT DATE: NONE PLATE: 3



DESIGNED BY: J. J. J. J.
CHECKED BY: R. J. J. J.
DATE: JULY 1985

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS

SEMO PORT MICRO MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47
AERIAL PHOTOGRAPH OF THE SEMO PORT
PRIOR TO THE CONSTRUCTION IN 1985

DATE SCALE

DATE 8/85

PAGE

4



PREPARED BY: J. ABBOTT
CHECKED BY: R. DAVENPORT
DATE: JULY 1989

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI	
SEMO PORT MICRO-MODEL STUDY MISSISSIPPI RIVER MILES 49 - 47 Current aerial photograph of the SEMO ₄ Port	
DESIGN FILE: PLOT SCALE:	PLATE NO. 5



Point of the port as seen from the river road.



Lower level of the river side of SEMO Port



PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: JULY 1998

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Photographs showing the configuration of SEMO Port

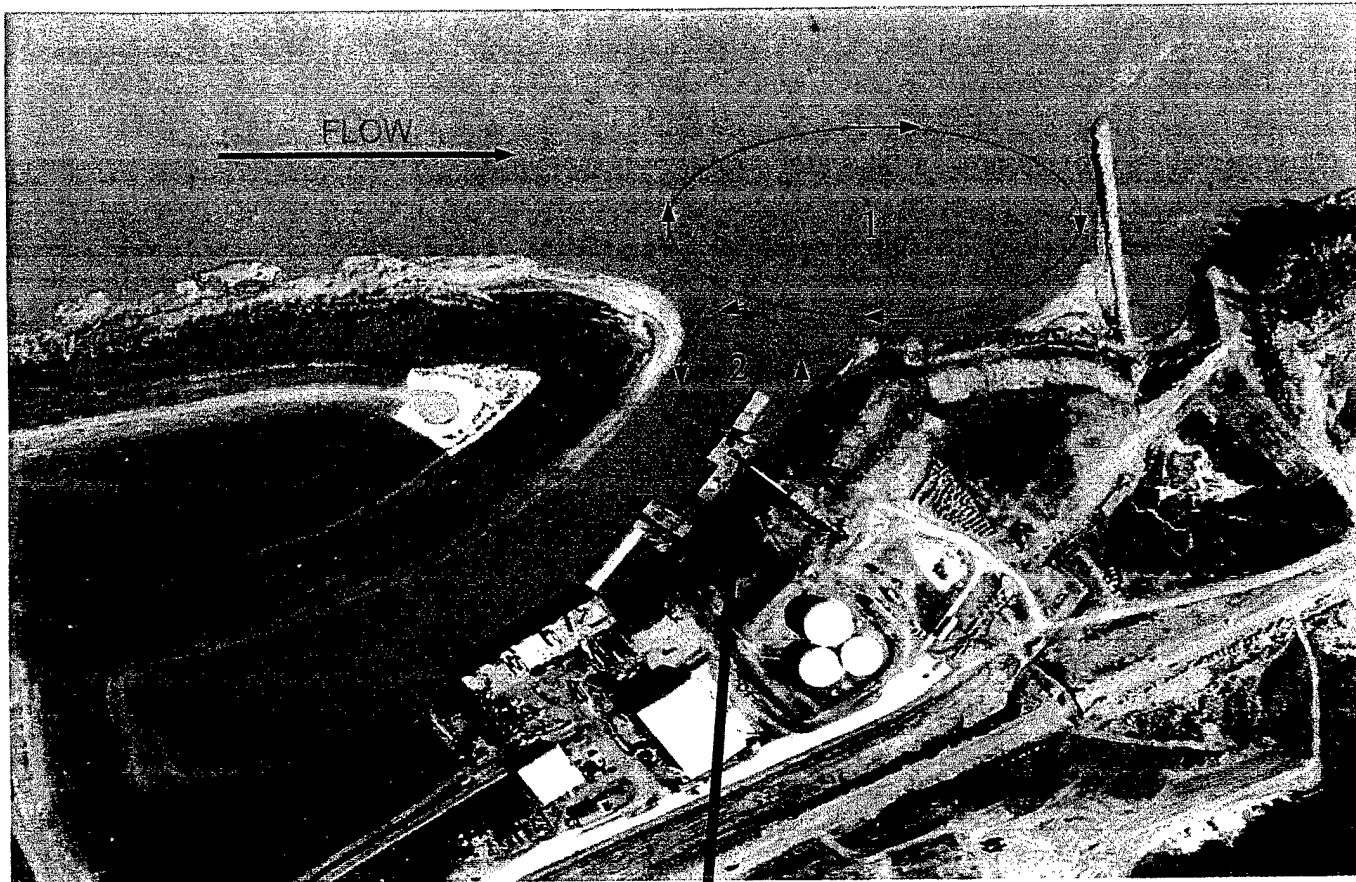
DESIGN FILE:

PLOT SCALE:

PLOT DATE: 8/5/99

PLATE NO.

6



PREPARED BY: A. RHOADS
CHECKED BY: R. DAVINROY

DATE: JULY 1999

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

OBSERVED EDDIES DURING FIELD RECONNAISSANCE

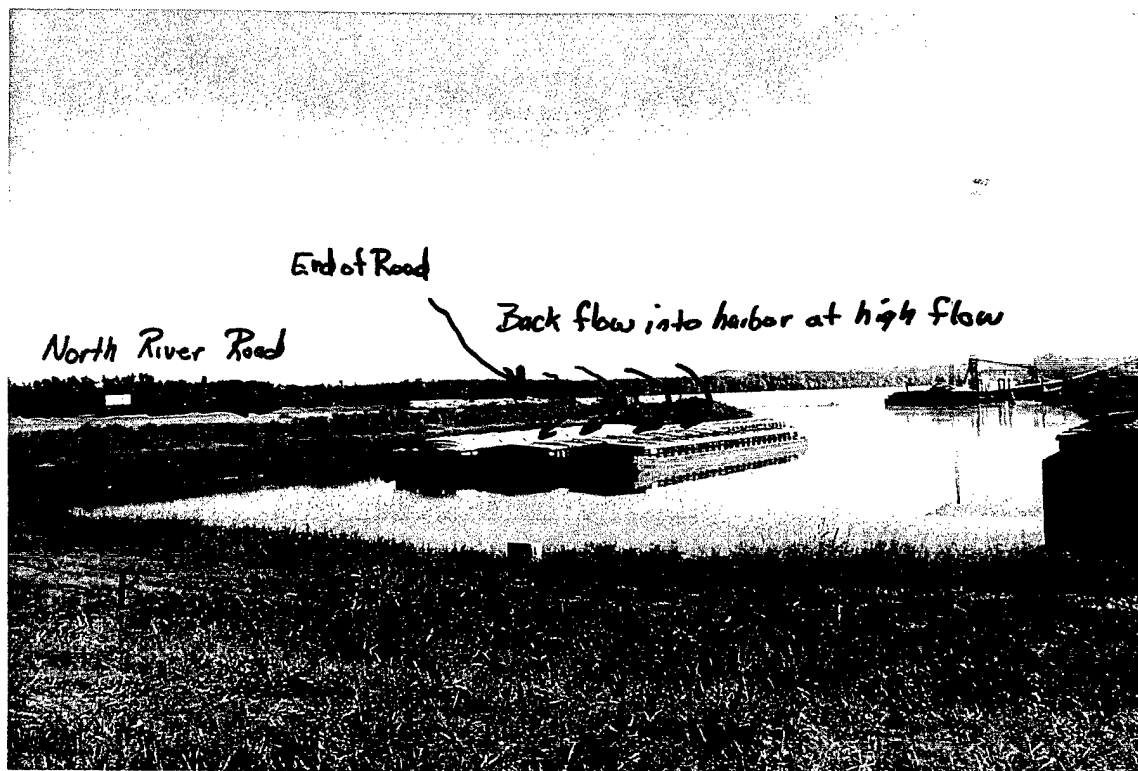
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PLATE NO.

PLOT SCALE:

PLOT DATE: 8/18/99

7



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: JULY 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Photograph showing the berm and river road.

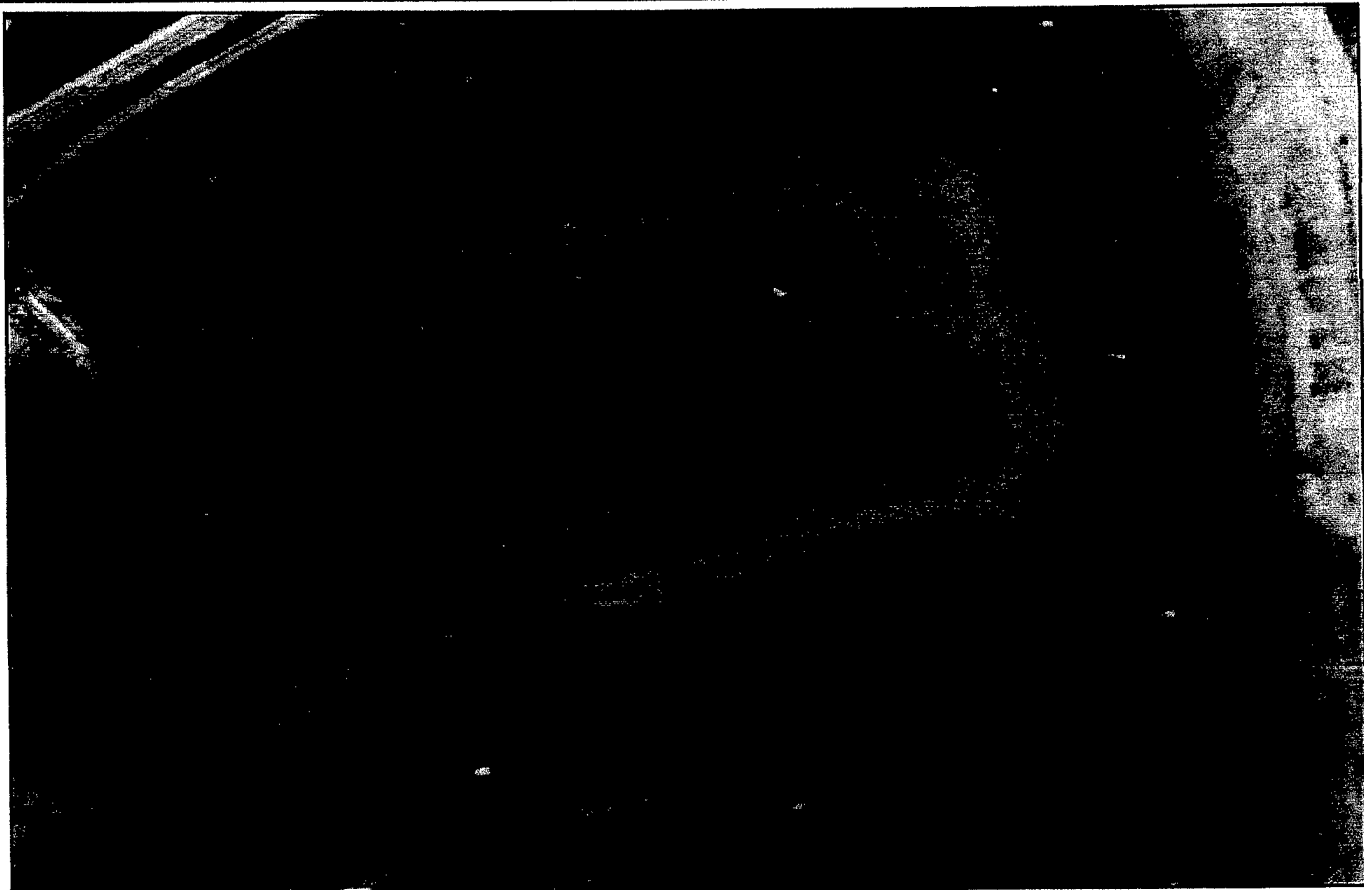
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PLOT SCALE:

PLOT DATE: 8/5/99

PLATE NO.

8



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

Prepared by: J. Abbott
Checked by: R. Davinroy

SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

DATE: JULY 1999

Diagram of erosion ditches

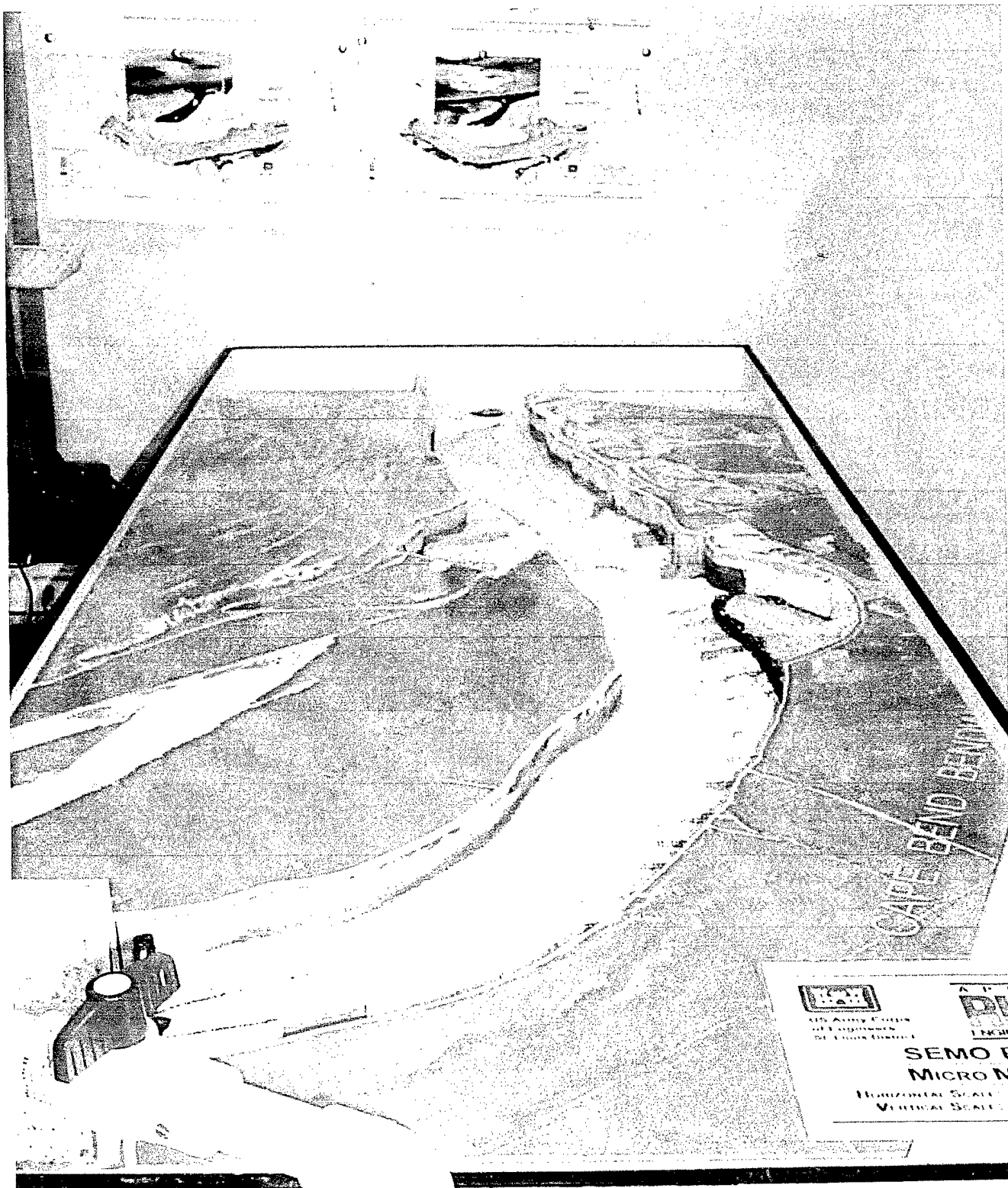
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PLATE NO.

PLOT SCALE:

Plot date: 8 / 5 / 99

9



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

Prepared by: J. Abbott
Checked by: R. Davinroy

SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

DATE: JULY 1999

DESIGN FILE: D:\PROJECTS\SEMO\PORT\MODEL\PIC

PLATE NO.

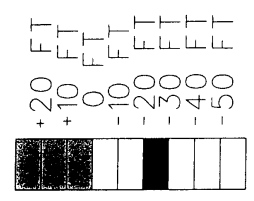
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Plot date: 8 / 5 / 99

10



Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

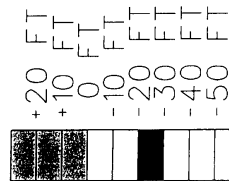
PREPARED BY J. ABBOTT
CHECKED BY R. DAVAROV
DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47
Hydrographic Survey
February 1995

DESIGN FILE: D:\projects\semaport\dm\plot\saunv9
PLOT SCALE: 1" = 1025'
PLOT DATE: 7/7/99



Elevations Referenced
to LWRP



PREPARED BY: J. ABBOTT
CHECKED BY: R. DAVINROY
DATE: NOVEMBER 1998

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47
Hydrographic Survey
August 1995

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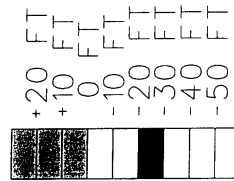
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PLATE NO.

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Elevations Referenced
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U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47
Hydrographic Survey
1996

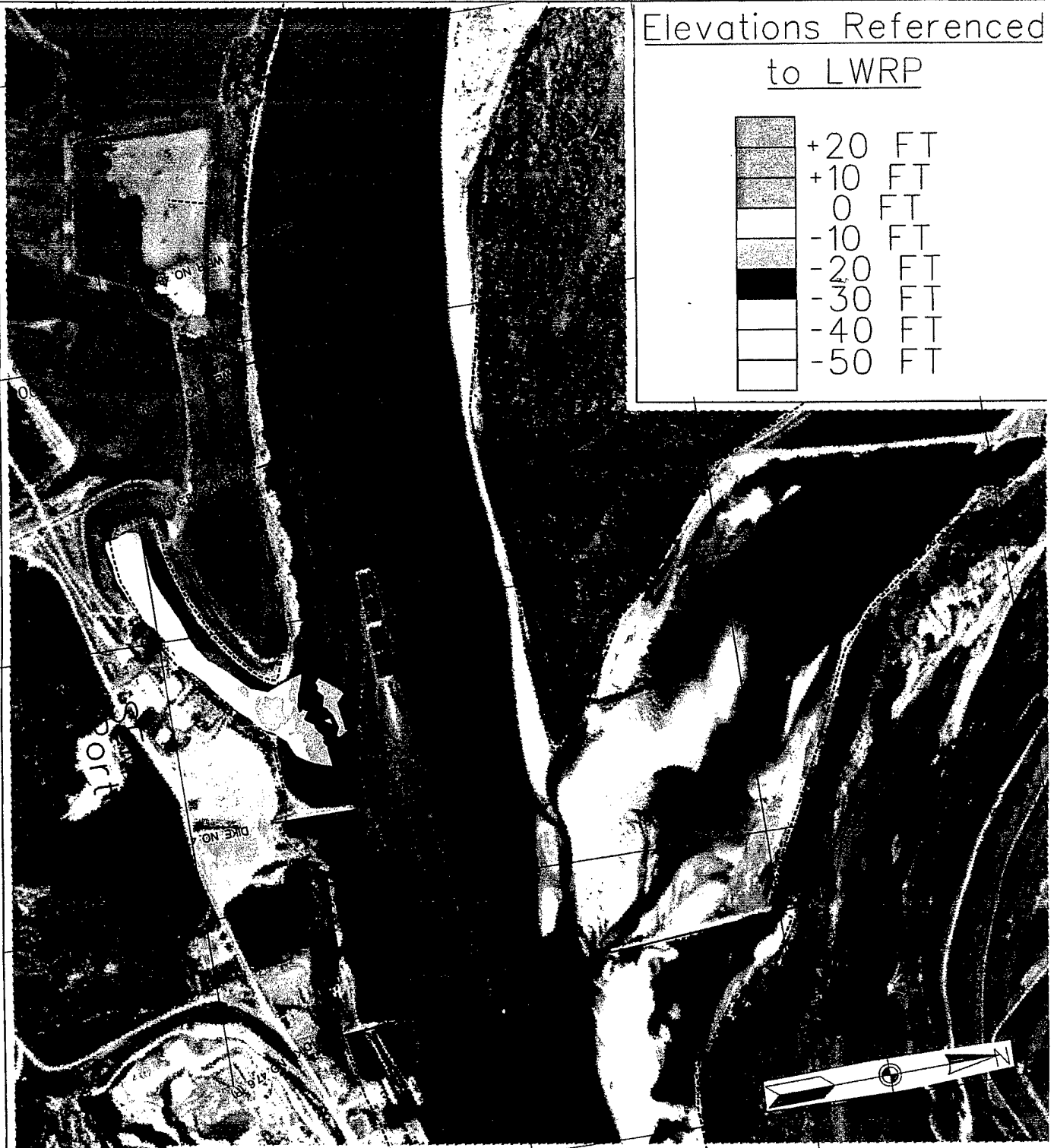
PREPARED BY: J. ABBOTT
CHECKED BY: R. DAWIDY
DATE: NOVEMBER 1998

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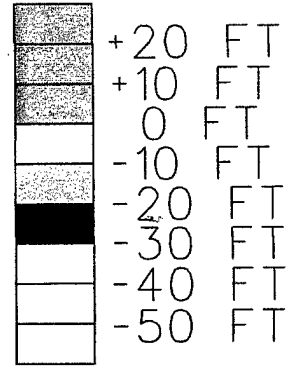
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PLOT SCALE: 1" = 1025' PLOT DATE: 7/02/98

13



Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Hydrographic Survey
December 1991

DESIGN FILE: D:\projects\semoport\dgn\protosurv1

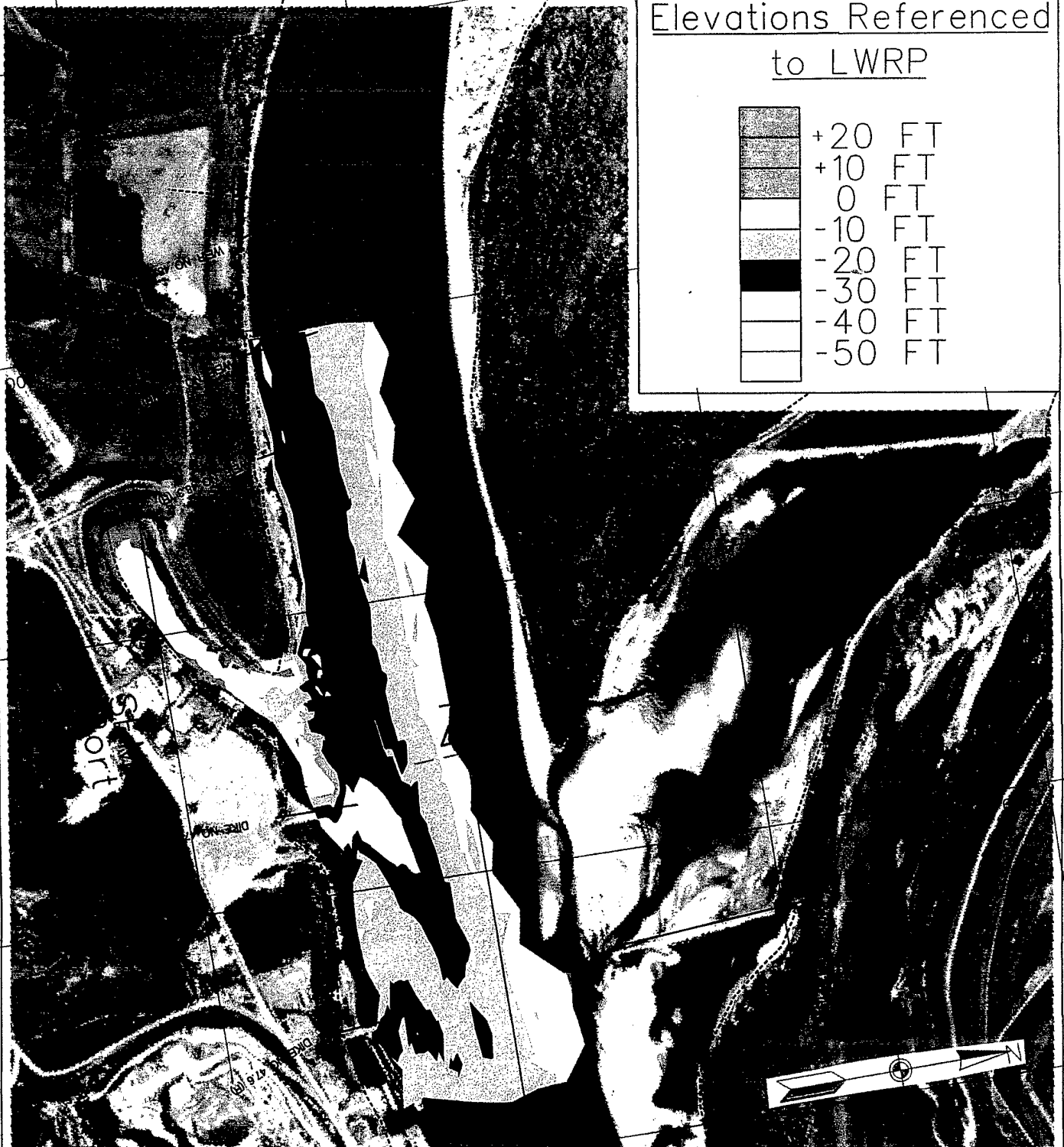
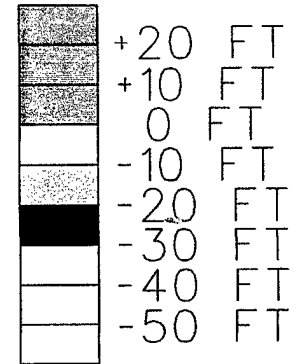
PLATE NO.

PLOT SCALE: 1" = 1025'

PLOT DATE: 7/7/99

15

Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Hydrographic Survey
December 1994

DESIGN FILE: D:\projects\semoport\dgn\protosurv2

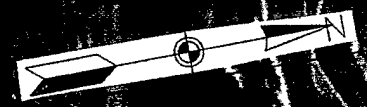
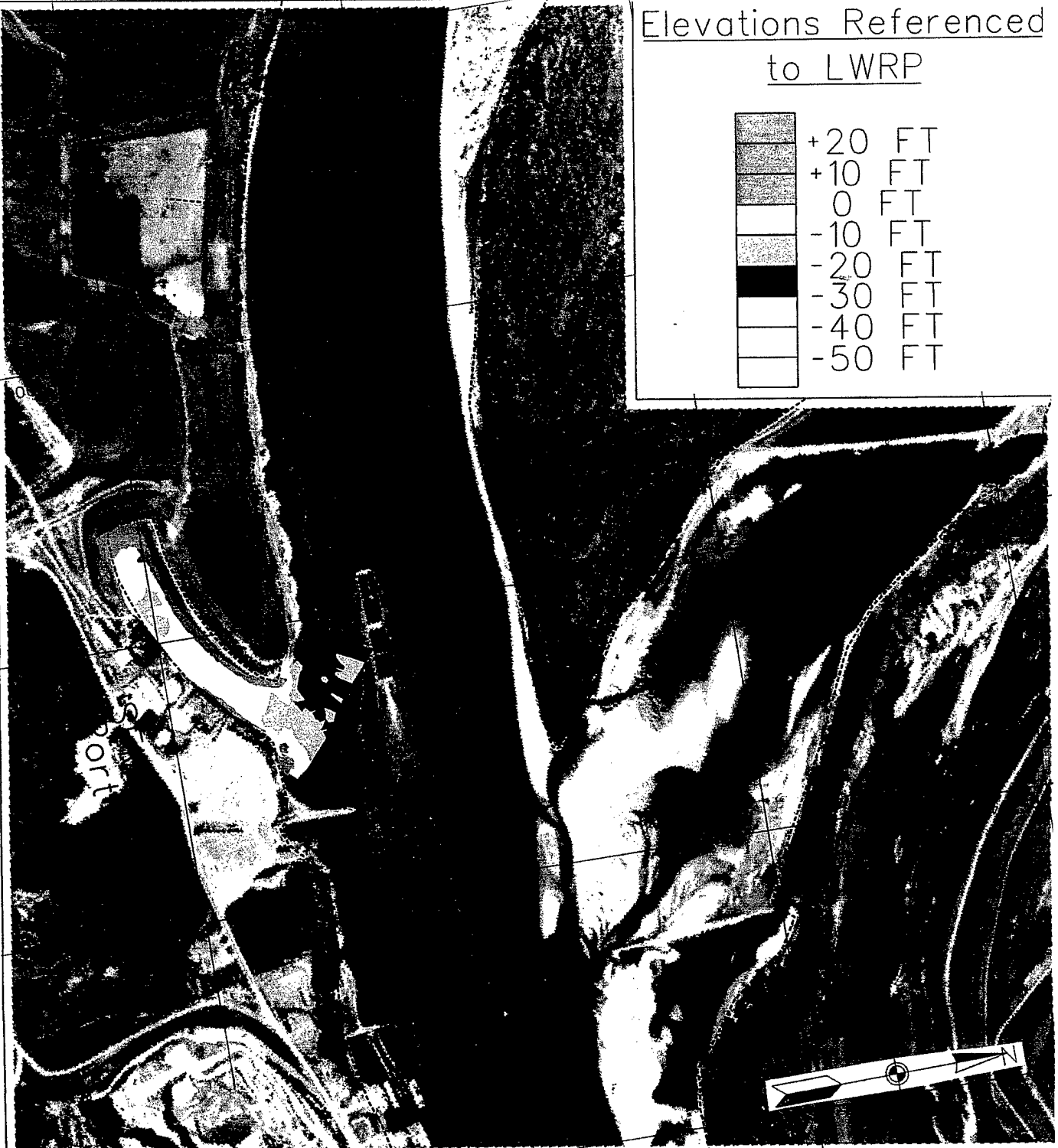
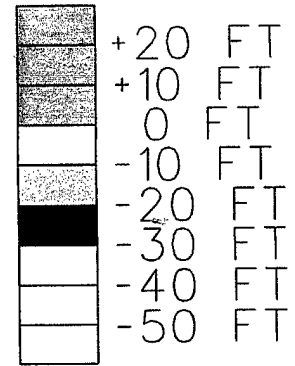
PLATE NO.

PLOT SCALE: 1" = 1025'

PLOT DATE: 7 / 7 / 99

16

Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Hydrographic Survey
August 1995

DESIGN FILE: D:\projects\semoport\dgn\protosun7

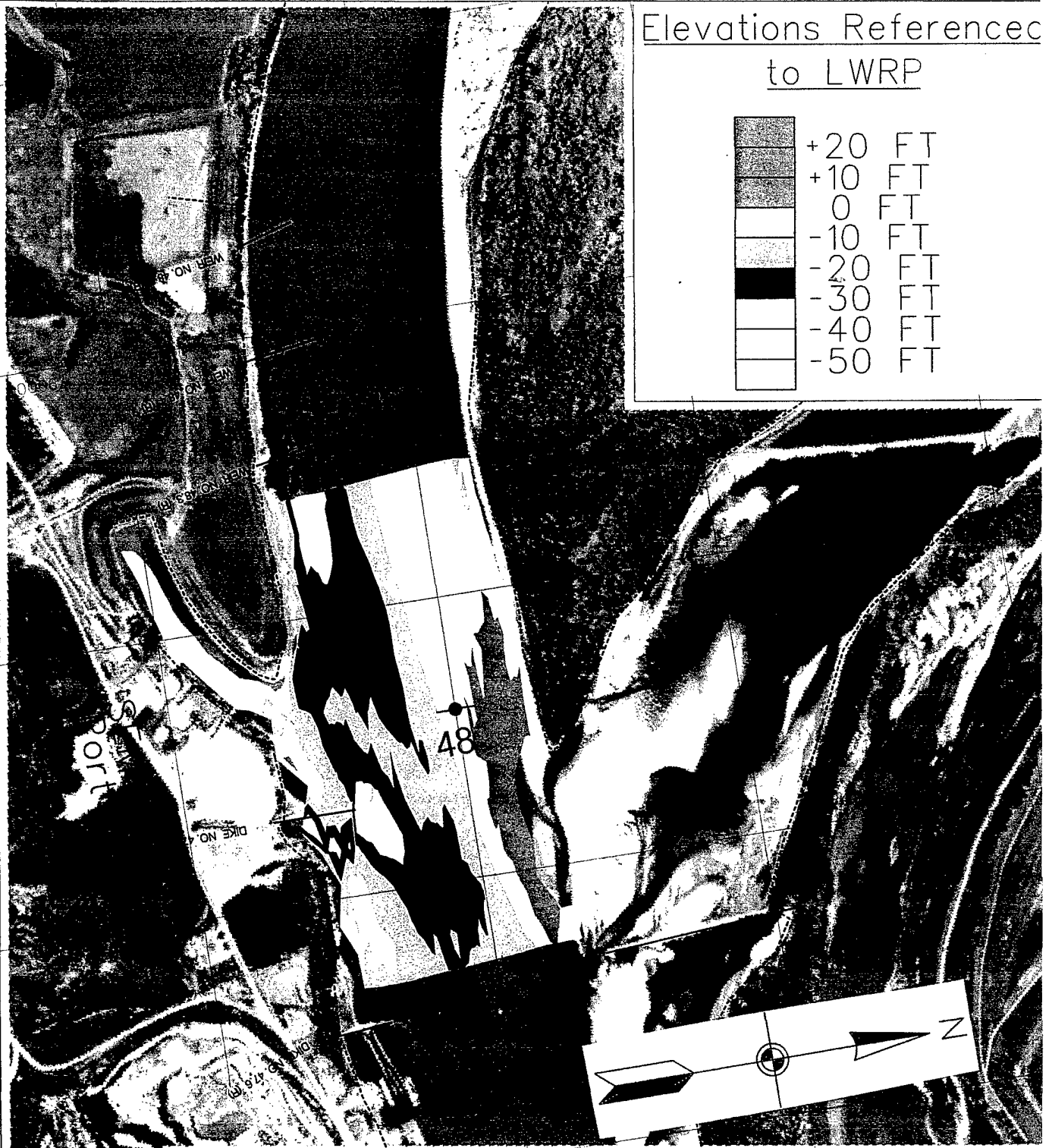
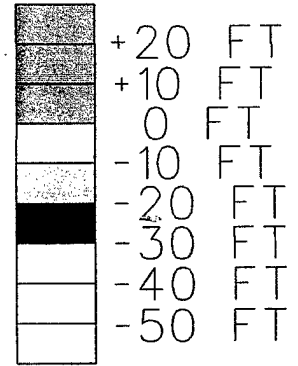
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PLOT SCALE: 1" = 1025'

PLOT DATE: 7 / 7 / 99

17

Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Hydrographic Survey
December 1995

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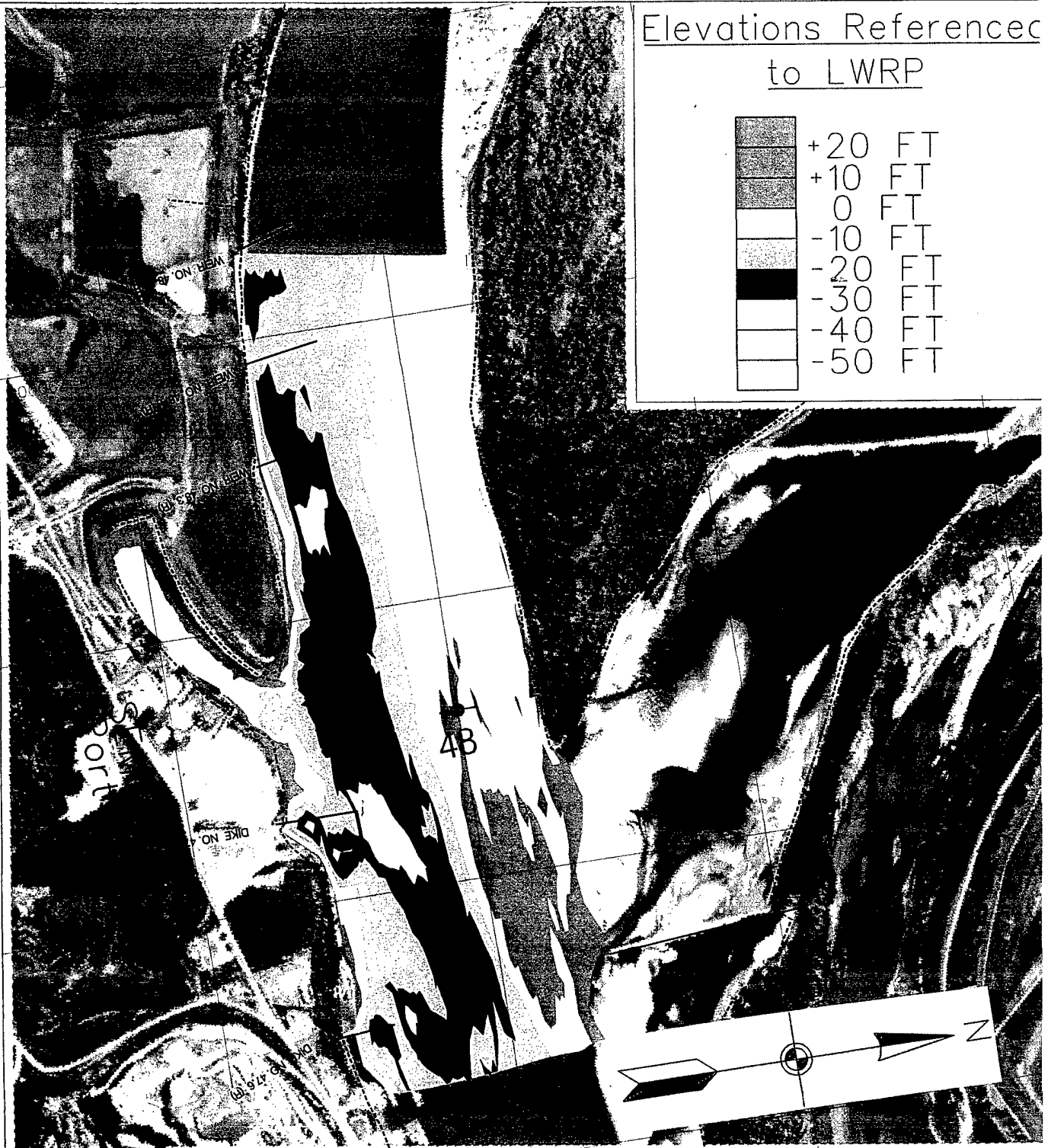
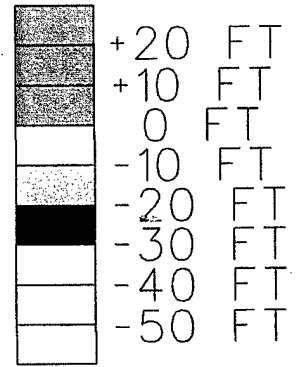
PLATE NO.

PLOT SCALE: 1" = 1025'

PLOT DATE: 7/7/99

18

Elevations Referenced to LWRP



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ST. LOUIS, MISSOURI

PREPARED BY: J ABBOTT
CHECKED BY: R DAVINROY

DATE: NOVEMBER 1998

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Hydrographic Survey

October 1996

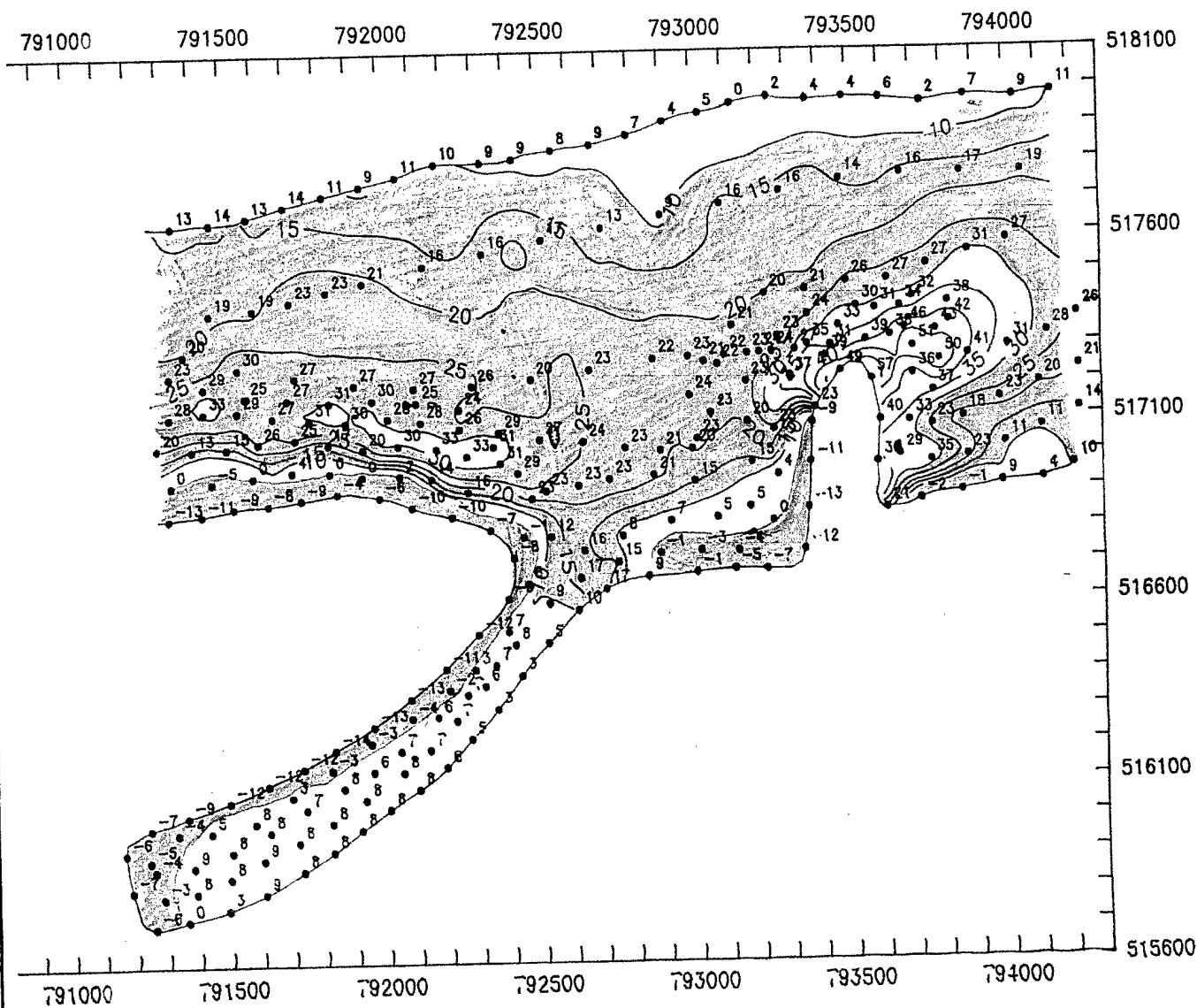
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PLATE NO.

PLOT SCALE: 1" = 1025'

PLOT DATE: 7/7/99

19



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

Prepared by: J. Abbott
Checked by: R. Davinroy

**SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47**

DATE: JULY 1999

Hydrographic Survey
October 1996

DESIGN FILE: D:\PROJECTS\SEMO\PORT\SURVEY1196

PLAT NO.

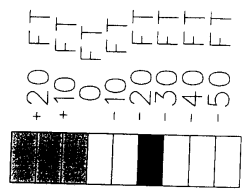
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Plot date: 8/5/99

20



Elevations Referenced
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U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY J. ABBOTT
CHECKED BY R. DAVARROY
DATE NOVEMBER 1998

SENIO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Base Test w/o Weirs

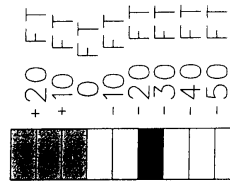
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PLOT DATE 06/10/99

PLATE NO

21



Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
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ST. LOUIS, MISSOURI

PREPARED BY: J. ABBOTT
CHECKED BY: R. DAVINROY
DATE: NOVEMBER 1998

SEMO PORT M CRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Base Test w/ Weirs

DESIGN FILE: D:\project\semoport\ogin\basest.dgn

PLATE NO

PLOT SCALE: 1" = 1025'

PLOT DATE: 09/27/98

22



**U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS**

Prepared by: J. Abbott
Checked by: R. Davinroy

**SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47**

DATE: JULY 1999

FLOW VISUALIZATION USING DYE

DESIGN FILE: FLOWDYE.PUB

PLATE NO. .

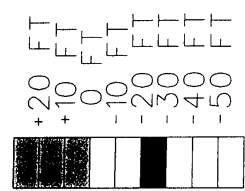
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Plot date: 8/5/99

23



Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. ABBOTT
CHECKED BY: R. DANNHOY
DATE: NOVEMBER 1998

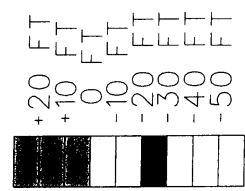
SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49-47
ALTERNATIVE 1

FOUR WEIRS BETWEEN MILE 48.2 AND 47.8
DIKE 47.9 REMOVED

DESIGN FILE: D:\projects\semoport\figh\alternatives
PLOT SCALE: 1" = 1025'
PLOT DATE: 10/07/98
PLATE NO. 24



Elevations Referenced
to LWRP



U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

PREPARED BY: J. ABBOTT
CHECKED BY: R. DANNHOY
DATE: NOVEMBER 1986

SEMO PORT MICRO-MODEL STUDY
MISSISSIPPI RIVER MILES 49-47

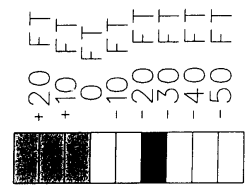
ALTERNATIVE 2


SEVEN WEIRS BETWEEN MILES 48.2 AND 47.7
DIKE 47.9 REMOVED

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PLATE NO. 25



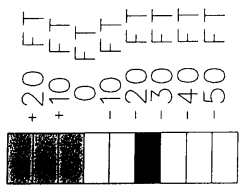
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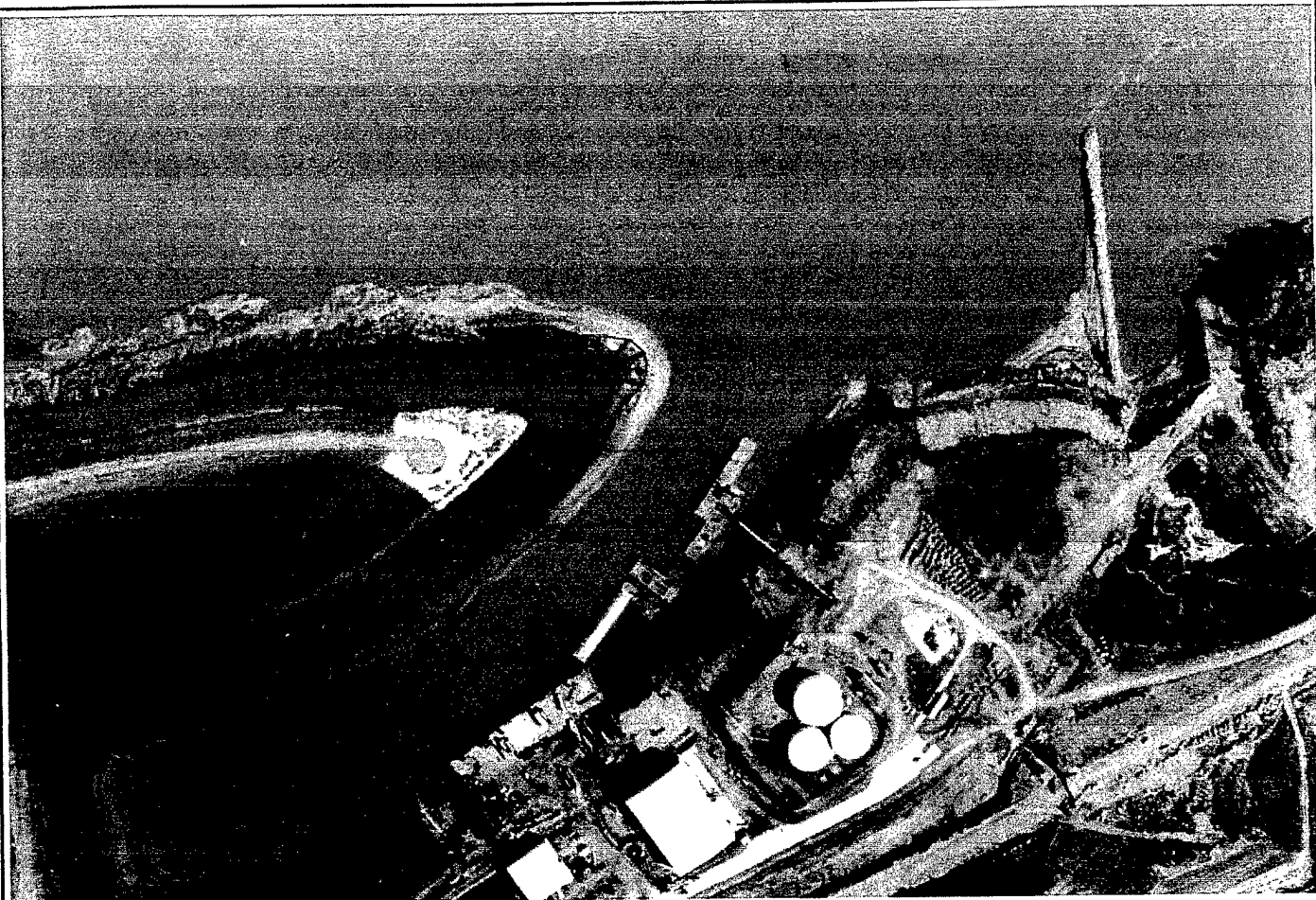
 PREPARED BY: J. ABBOTT CHECKED BY: R. DAWROD DATE: NOVEMBER 1998	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI	
	SEMO PORT MICRO-MODEL STUDY MISSISSIPPI RIVER MILES 49-47 ALTERNATIVE 4	
FOUR WEIRS AT MILE 48.2 WITH ANGLES OF 40 DEGREES WITH UNDERWATER ROCK POINT ADDED		DESIGN FILE: D:\project\semoport\cogn\semoport\semoport.mxd PLOT SCALE: 1" = 1000' PLOT DATE: 01/07/98 PLATE NO. 27



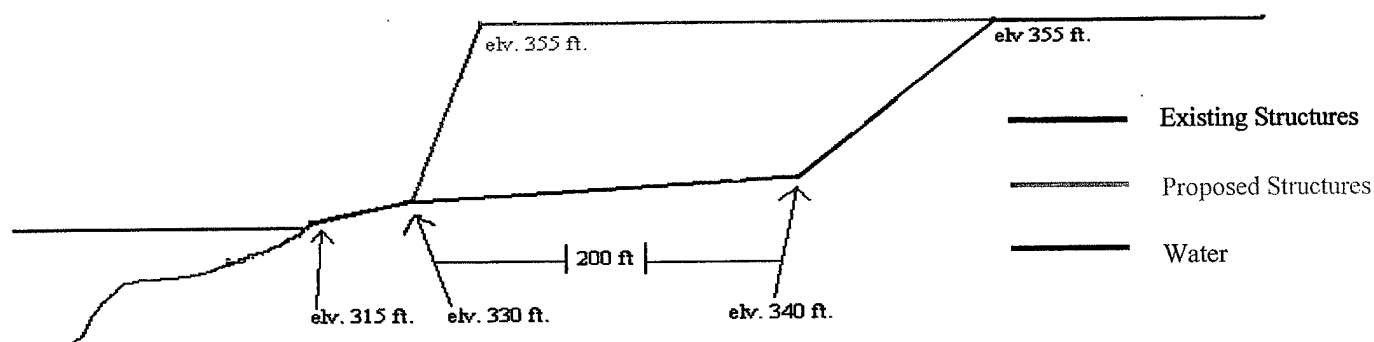
Elevations Referenced
to LWRP



 PREPARED BY: J. ABBOTT CHECKED BY: R. DAVENPORT DATE: NOVEMBER 1998	U.S. ARMY ENGINEER DISTRICT, ST. LOUIS CORPS OF ENGINEERS ST. LOUIS, MISSOURI
	SEMO PORT MICRO-MODEL STUDY MISSISSIPPI RIVER MILES 49-47 ALTERNATIVE 5
	REMOVAL OF DIKE 47.9 AND BANKLINE FILL AT MILE 48.0 WITH UNDERWATER ROCK AT POINT ADDED
DESIGN FILE: d:\projects\semoport\lwrp\alt5\alt5.dgn PLOT SCALE: 1" = 1000'	
PLOT DATE: 8/07/98	
PLATE NO. 28	



Profile of proposed berm exstention.



PREPARED BY: J. ABBOTT
CHECKED BY: R. DAVINROY
DATE: JULY 1999

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS
ST. LOUIS, MISSOURI

SEMO PORT MICRO - MODEL STUDY
MISSISSIPPI RIVER MILES 49 - 47

Proposed Berm Extension

DESIGN FILE: D:\PROJECTS\SEMOPORT\PROPOSEDSOLI

PLATE NO.

PLOT SCALE:

PLOT DATE: 8/5/99

29